Estrogens in Coastal Waters

The Sewage Source

Although estrogens are essential for successful reproduction in animals, various estrogen metabolites and by-products in treated sewage could have deleterious effects on marine organisms if ingested or absorbed. In this issue, Shannon Atkinson, now at the University of Alaska Fairbanks, and colleagues from the Hawaii Institute of Marine Biology report for the first time the distribution of sampled steroidal (nonplant-derived) estrogens in coastal waters of tropical oceans [***EHP* 111:531–535**]. They found the highest concentrations near sources of sewage effluent.

Swimming in estrogens. New data show that steroidal estrogens are seeping into coastal environments.

Vertebrates excrete estrogens in the form of water-soluble polar conjugates. Synthetic steroidal estrogens excreted by humans include those found in birth control pills and hormone replacement therapies, which are among the most-prescribed pharmaceuticals in the United States. Lab experiments on sponges, crustaceans, mollusks, and echinoderms have shown a variety of harmful effects attributable to estrogens in varied forms and concentrations under a range of conditions. But it is not known how steroidal estrogens released into the environment affect growth, development, and reproduction of invertebrates, the foundation of marine food webs and ecosystems.

The researchers collected 129 water samples at 20 sites representing a range of coastal land uses and sewage inputs, from an arid, uninhabited coastline to a sewage treatment facility. Samples included both raw and treated sewage. One sample was taken from a completely contained, isolated coral reef ecosystem in the enclosed Biosphere 2 ocean in Arizona. All others were taken from Pacific, West Atlantic, and Caribbean coastal seas. Sampling locations ranged between 2 meters and 1 kilometer from shore, with most samples collected within 100 meters of shore.

Estrogens were concentrated by chromatography and assayed using a highly specific radioimmunoassay for estrone, a reduced form of estrogen. Concentrations of unconjugated estrone—which is generally more biologically active than conjugated estrone—ranged from undetectable (less than 40 picograms per liter [pg/L]) in the open ocean to nearly 2,000 pg/L in embayed areas near population centers. Estrone concentrations were highest near sources of sewage. Concentrations in embayed sites that received effluent were 1–2 orders of magnitude higher than in open ocean waters.

The lowest estrone concentrations were from open ocean samples taken in tropical regions near the Hawaiian Islands, the Marianas Islands, French Polynesia, and the Florida Keys, with averages of 15–52 pg/L. The sample from the Biosphere 2 ocean had the next lowest concentration (66 pg/L), indicating that high residence time of water over the reef community—in this case, eight years—does not necessarily create high concentrations of estrogen. The highest estrone values were from shallow embayments with known sewage inputs: Delaware's Rehoboth Bay (1,870 pg/L) and Key West Harbor (1,580 pg/L).

Effluent is not the only route through which excreted estrogens enter aquatic environments. In the researchers' experiments, estrogens filtered easily through gravel and sand, showing less than 20% adsorption, which indicates they can leach into the marine environments from septic fields and groundwater. Poorly flushed bays and lagoons known to receive sewage from septic fields and injection wells had built up estrogens to concentrations within a factor of 10 of those measured in sewage effluent.

Interestingly, unconjugated estrogens analyzed during one laboratory experiment were higher in a sewage sample (54%) than in two seawater samples (34% and 35%). One would expect higher concentrations of polar conjugates in treated effluent because its source is human waste, says Atkinson. The high percentage of unconjugated estrogens detected suggests that bacterial activity in the sewage may be converting the compounds back to a biologically active form.

About one-half to two-thirds of total estrone in the study samples occurred as polar conjugates. Although reef-building corals can take up significant amounts of unconjugated estrone from the water, it is not known whether corals or other organisms similarly can take up conjugated estrogens. Additionally, various aerobic and anaerobic bacteria could hydrolyze these esters under appropriate conditions, providing a possible continual source of unconjugated estrogens in the marine environment.

These data indicate that coastal environments may have large pools of environmentally persistent estrogens with unknown repercussions for nearshore ecosystems. This study provides quantitative baseline data from coastal waters, which will inform future studies of the effects of estrogens and estrogen mimics on marine organisms at naturally occurring concentrations. More thorough sampling is needed to establish fluxes of estrogens, possible uptake and accumulation, and physiological responses of marine organisms. **–Carla Burgess**

Childhood Leukemia

Bad Air Linked to Increased Risk

Researchers in the Environmental Health Investigation Branch of the California Department of Health Services have discovered a possible association between exposure to hazardous air pollutants (HAPs) and the incidence of childhood leukemia [***EHP* 111:663–668**]. Their epidemiologic evaluation suggests that children living in areas of high ambient air pollution are at increased risk of developing leukemia.

Peggy Reynolds and her coauthors set out to evaluate whether childhood cancer rates were elevated in areas estimated to have high exposure to potentially carcinogenic HAPs. They used the population-based California Cancer Registry to gather information on all cancer cases diagnosed in children under age 15 from 1988 to 1994. They used a geographic information system to map nearly 7,000 childhood cases within individual California census tracts. Their analysis also examined the incidence of the most common childhood cancers—acute lymphocytic leukemia, acute nonlymphocytic leukemia, and gliomas (brain tumors).

On the pollution side of the equation, the investigators focused on 25 of the 189 HAPs identified in 1990 as potential human carcinogens by the U.S. Environmental Protection Agency (EPA). These 25 compounds—which included benzene, dioxins, lindane, and vinyl chloride—were selected because they had the best information on their potential to cause cancer via inhalation. The investigators also

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utilized an EPA dispersion model that combined 1990 emissions inventories with meteorologic data to estimate the annual HAP concentration for each census tract in the country.

Following the EPA model, they estimated which California census tracts had the greatest HAP exposures. They calculated census tract emission scores for all sources combined, as well as for three distinct source categories: mobile sources (such as motor vehicles, planes, trains, and ships), area sources (such as dry cleaners, gas stations, residences, farm pesticide use, and forest fires), and point sources (large industrial manufacturing facilities). For each of these emission source groups, they further calculated exposure scores for each census tract by multiplying the modeled air concentration by the corresponding inhalation unit risk factor for each HAP. The inhalation unit risk factor combines the cancer potency for each compound with standard assumptions for body weight and breathing rate.

When they ran the exposure score data and the cancer case incidence data through statistical analysis, they found little evidence of an increased risk of gliomas. However, they did find the risk of both types of leukemia to be elevated by 21% in census tracts with the greatest overall HAP exposure. More disturbingly, they found the most dramatically elevated childhood leukemia incidence rates—a 32% increase—within census tracts with the highest HAP exposure from industrial facilities. The association was even greater in children aged 0–4 years, which the investigators speculate may be due to the fact that younger children tend to spend more time at home than older ones.

Of course, many other factors could contribute to the development of cancer in children, including individual susceptibility and exposure to indoor pollutants such as environmental tobacco smoke. The authors acknowledge the inherent limitations of their investigation, but conclude that it "suggests that background air quality, as estimated by HAPs, may be associated with incidence of childhood leukemia." They have begun a follow-up study focusing more closely on the relationship between cumulative exposure to HAPs and childhood leukemia, which will include questionnaire information on personal activity patterns and indoor pollution sources. **–Ernie Hood**

A Diet Rich in Fish

High-End Consumers Face More Mercury Risks

Fancy fish aficionados, take note: if your forays into piscatorial paradise are frequent, you could be ingesting dangerously high amounts of mercury. In this month's issue, Jane Hightower and Dan Moore of the California Pacific Medical Center in San Francisco report that people who often eat certain expensive commercially caught fish are at risk for excessive exposure to mercury [***EHP*** **111:604–608**].

Mercury can accumulate in the body if eaten at a greater rate than it is excreted. It can cause several well-documented adverse health effects, including impairment of the immune, cardiovascular, and reproductive systems.

The researchers evaluated all of the patients in a general internal medicine practice in San Francisco who came in for an office visit over a period of one year. A total of 720 mostly middle- to upper-income patients were asked to estimate how much they ate of several types of fish. Of these, 93 females and 30 males (including 7 children under age 12) warranted having their mercury levels measured, either because of their fish consumption habits or because they presented with symptoms consistent with mercury overexposure (such as fatigue, decreased memory, and joint pain).

Thirty-four subjects, including all the children, were excluded from further analysis because of various confounding factors. The researchers did note, however, that the mean mercury level for all the women in the survey was 10 times that found in a recent population survey by the Centers for Disease Control and Prevention. Some of the children had over 40 times the national mean.

For the 89 subjects whose blood results underwent statistical analysis, the findings were alarming. Ninety-two percent of these subjects had blood mercury concentrations above 5 micrograms per liter (µg/L), the maximum level recommended by the U.S. Environmental Protection Agency and the National Academy of Sciences. Eighteen percent had concentrations above 20 µg/L.

Those participants with higher blood mercury appeared to have eaten more of the large predator species, particularly swordfish and ahi. These types of fish (which are consumed as steaks, sushi, or sashimi) are often more expensive. However, the study subjects were relatively affluent and were not deterred by price. Thus the researchers feel they have identified a subpopulation at risk for mercury overexposure, with higher income and education the most apparent risk factors.

The good news to emerge from the study is that dangerously high blood mercury is reversible, although it can take several months to reduce levels to an acceptable point. The researchers followed 67 subjects over time after they stopped or greatly reduced their consumption of moderate- to high-mercury-content fish. Their blood mercury declined rapidly in the first three weeks, followed by a slower reduction over time. After 41 weeks, all but two patients, who continued to eat large predatory fish, had reduced their level to below 5 µg/L.

Current wisdom holds that eating fish high in omega-3 fatty acids is a good way to prevent heart disease and enhance nutrition. Yet the mercury concentrations in some fish may be enough to counter these good effects. According to Hightower and Moore, clinicians should be alert for patients who may present with side effects caused by the contaminants that are present in many fish. They recommend that dietary histories encompassing fish consumption become part of a comprehensive health screening to identify people at risk for mercury accumulation.

Because adverse effects in children are believed to occur when the pregnant mother's blood mercury level is more than 15 µg/L, prepregnancy screening is important for patients who eat fish frequently. The researchers also point out that more testing of fish for mercury content is needed, and they urge that information and advisories resulting from further testing be made readily available to consumers where fish is sold. **–Ernie Hood**

Worth the cost? Consumers of expensive predator fish, sometimes eaten as sushi or sashimi, may expose themselves to greater mercury risks.

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